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Proceedings Series 2002/018 | **Série des compte rendus 2002/018**

Proceedings of a Maritimes Regional Advisory Process Meeting on SPA 1 – 4 Scallops

10 – 12 October 2001
Bedford Institute of Oceanography
Dartmouth, Nova Scotia

Compte rendu d'une réunion du Processus consultatif régional des Maritimes au sujet des pétoncies des APP 1 à 4

du 10 au 12 octobre 2001
Institut océanographique de Bedford
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July 2002 / juillet 2002

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ISSN 1701-1280
www.dfo-mpo.gc.ca/csas/
Canada

102-06534/

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July 2002

Foreword

The purpose of these proceedings is to archive the activities and discussions of the meeting, including research recommendations, uncertainties, and to provide a place to formally archive official minority opinions. As such, interpretations and opinions presented in this report may be factually incorrect or mis-leading, but are included to record as faithfully as possible what transpired at the meeting. No statements are to be taken as reflecting the consensus of the meeting unless they are clearly identified as such. Moreover, additional information and further review may result in a change of decision where tentative agreement had been reached. Additionally, any summary on the stock status presented in these proceedings should not be referenced.

Avant-propos

Le présent compte rendu fait état des activités et des discussions qui ont eu lieu à la réunion, notamment en ce qui concerne les recommandations de recherche et les incertitudes; il sert aussi à consigner en bonne et due forme les opinions minoritaires officielles. Les interprétations et opinions qui y sont présentées peuvent être incorrectes sur le plan des faits ou trompeuses, mais elles sont intégrées au document pour que celui-ci reflète le plus fidèlement possible ce qui s'est dit à la réunion. Aucune déclaration ne doit être considérée comme une expression du consensus des participants, sauf s'il est clairement indiqué qu'elle l'est effectivement. En outre, des renseignements supplémentaires et un plus ample examen peuvent avoir pour effet de modifier une décision qui avait fait l'objet d'un accord préliminaire. Les brefs sommaires de rapport sur l'état des stocks présentés dans le présent compte rendu ne doivent pas non plus être considérés comme des textes de référence.

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ABSTRACT

A RAP meeting to review the assessment model for use on the SPA 1 – 4 scallop stocks was held during 10 – 12 October 2001 at the Bedford Institute of Oceanography. The meeting focused on the model and its data requirements and was not intended to produce advice on the status of the resources for the upcoming fisheries. A number of recommendations were made to improve the model, which are planned to be implemented in time for use in the next set of assessments.

RÉSUMÉ

Une réunion du PCR visant à examiner le modèle d'évaluation applicable aux stocks de pétoncle des APP 1 à 4 a eu lieu du 10 au 12 octobre 2001 à l'Institut océanographique de Bedford. Cette réunion portait sur le modèle et sur les données qu'il nécessite, mais elle n'avait pas pour but de produire d'avis sur l'état des ressources en vue des pêches prochaines. Diverses recommandations d'amélioration au modèle ont été formulées et on compte les mettre en œuvre à temps pour la prochaine série d'évaluations.

INTRODUCTION

A meeting of the Maritimes Regional Advisory Process (RAP) was held at the Bedford Institute of Oceanography (BIO) during 10 – 12 October 2001 to review the assessment model planned for use in the evaluation of the status of the SPA 1 – 4 scallop resources (appendix 1). It was noted at the beginning of the meeting by the chair (R. O'Boyle) that the meeting was not to be a review of the status of these stocks but rather of the assessment model to be used. It would be a highly technical discussion more in a workshop environment. It was noted that this approach is being considered for other Maritimes resources. Such separation of the model review from the assessment review will hopefully lead to better evaluations and advice. It was noted that the assessment of these resources for the 2001/2002 fishing season is planned for late November / early December. It was recommended that the model developed at this meeting be used in this assessment.

The list of meeting participants is provided in appendix 2, with the letter of invite in appendix 3. A number of external reviewers had been invited to the meeting, including S. Harley (Dalhousie Univ.), S. Gavaris (SABS), D. Hart (NEFSC, US), and R. Mohn (BIO), based on their knowledge of scallops and quantitative expertise. Other participants included the scallop team at BIO, other scientists from DFO and aboard, fisheries managers and industry participants. In the case of the latter, it was agreed that the results of the meeting would be provided to the Inshore Scallop Advisory Committee (ISAC) by S. Smith, with R. O'Boyle in attendance if required.

After the introduction, management issues related to use of the model were discussed. Then, S. Smith gave a presentation of his paper, entitled:

> Smith, S.J. 2001. Application of Biomass Dynamic Models to the Bay of Fundy Scallop Stocks. RAP Working Paper 2001/057.

This was followed by section-by-section review of the model, with the discussion and recommendations recorded by the chair and S. Smith for later incorporation into these proceedings. These proceedings follow the terms of reference of the meeting.

MANAGEMENT ISSUES

The model was developed to assess the SPA 1 and 4 scallop resources. Along with the biology of scallop, it considered the types of data (e.g. catch, size composition, surveys) available for these areas. The model was an 'actuarial' approach to the determination of stock status in that no stock / recruitment function is used or assumed. The model effectively determines how many scallop are present once they have settled in an SPA, using a time series or State Space approach (scallop at stage n and time t are a function of scallop at stage n -1 and time t – 1).

- The meeting considered that the assessment framework would be appropriate for SPAs 1, 3, 4 and 6, recognizing that it would have to be modified to account for data availability differences among the areas.

It would be expected that, given biological differences among the areas (e.g. differing growth rates between SPA 1 and 4), the derived parameters would be different.

DATA CONSIDERATIONS

Commercial Catch, Effort and Sampling

It was noted that for the data prior to 1976, a number of assumptions had been made to partition the catch and effort data by SPA. These assumptions need to be revisited and confirmed, work that is already planned.

- It was recommended that the assumptions made to partition the historical catch and effort data by SPA be reviewed and changes made as appropriate.

It was pointed out that during 1987 – 92, problems were experienced in the reporting of catch and effort statistics, which the model has addressed through use of a variance term. However, while commercial sampling data exists from 1991 to the present, such information is not available prior to this and growth curves have to be used to determine the size composition of the catch. It was reported that some historical information does exist.

- It was recommended that the historical catch sampling information be explored to corroborate the model results.

Commercial catch rates (CPUE) were used as indicators of the recruited biomass (about age 4+ before 1997 and age 5+ subsequently). The initial model formulation used CPUE calculated as the sum of catch over sum of effort. It was considered that account of vessel, season and area effects need to taken.

- It was recommended that a catch/effort standardization be used to produce the CPUE indicator.

Surveys

The survey data is used in the initial model to track trends in the recruit biomass (age 3 prior to 1997 and age 3 and 4 subsequently). Given the reporting problems during 1987 – 92 noted above and survey consistency problems noted below, the possibility of using only the post 1990 data was discussed. However, the indicator undergoes a decline since 1991 (so-called 'one-way' trip) and is thus non-stationary. During model investigations using this shorter time series, a strong correlation between recruit biomass and the associated catchability was observed. The model was unable to determine stock trends when there is such a monotonic

trend in the indicator time series. It was speculated that this would not be a problem using the longer, stationary, time series.

- It was recommended that the entire survey time series be used to develop stock indicators.

Using the survey data available since 1981 assumes that the time series is consistent over this period. However, there have been a number of changes to the survey data set that might invalidate this assumption. For instance, the strata boundaries used during 1981 – 1990 and subsequently are different, making post-stratification of the historical data necessary. Gear changes have also been made over time. Efforts to make the series more consistent over time will continue. It was also suggested that the model might use different survey catchabilities before and after 1991. However, given the time trends in the series, this might not be appropriate. No other solutions could be suggested. Eventually, the historical data will have limited impact on the assessment and might be excluded from the analysis.

The survey indicator used in the model is based upon sampling of a core area, which has been undertaken since 1981. Since 1991, sampling outside of the core area has been more extensive. This effectively assumes that the proportion of biomass outside the core survey area has been constant. This assumption needs to be confirmed.

- It was recommended that commercial catches be used to examine long-term changes in the proportion of biomass inside and outside of the core survey area.

It was suggested that the survey be checked for its ability to track year-classes.

- It was recommended that the year-class continuity in the survey series be examined.

MODEL CONSIDERATIONS

States

The initial model structure consisted of two states: recruits and recruited scallop, where these terms applied to the fishery and not the population. However, changes in the fishery have required a change in the definition of these groups. The recruits refer to scallops with shell heights between 55 and 80 mm from 1981 to 1995 and 75 to 95 mm since then. Similarly, the recruited refers to scallops with shell heights greater than 80 mm from 1981 to 1996 and greater than 95 mm since then. The initial model however used the same catchability and individual weight change between the two components over the whole time series. Discussion ensued on how the split the series. If the split were made at 95 mm for whole series, prior to 1997, the recruits would include fishing mortality (at 75-95 mm sizes), which would be significant. If the split were made at 80 mm for whole series, it might be possible to split out the 95mm group in the most recent period using the commercial sampling information. However, a better approach would be to model the age groups moving through the population. In this case, the 55 – 80 mm, 80 – 95 mm and 95+ mm groups represent ages three, four and five plus respectively.

The initial model was modified to consider these age groups and the results compared to the initial model. The results of the two models were not dissimilar but the three age group model has a better biological rationale.

- It was recommended that the model assess age groups rather than size groups in the fishable population; this model would form the basis for further development.

There was discussion on how the indicators tracked events in the modeled fishery. It was emphasized that the assessment and management year should be the same, which is being done. Further model enhancements could involve the addition of more temporal and spatial structure.

Indicator – State Relationships

Commercial Catch Rate

A problem was noted with using CPUE as an indicator. There was uncertainty as to whether or not the relationship between CPUE and age 4 and 5+ biomass was linear or non-linear. There was some evidence from the model fits of non-linearity, with proportionally higher CPUE at high survey biomass. This would indicate the need to add a power term to the relationship. However, without adding a survey indicator of age 5+ biomass to the model, this relationship will not be well estimated. One could argue that incorporating an age 5+ survey indicator to the model is a better approach anyway (but has its own problems – see below). However, understanding the relationship between commercial catch rates and stock biomass would be important in interpreting the economics of fleet dynamics as well as assist communication with the industry.

- It was recommended that a survey indicator be developed for the age 5+ biomass. Then a power relationship between CPUE and model age 5+ biomass could be investigated.

As noted above, a variance term was put in the model to account for reporting problems. The sensitivity of the model to this parameter requires investigation.

- It was recommended that the sensitivity of the model to the reporting variance parameter be investigated.

Survey Catch Rates

The model tracks biomass rather than numbers. The commercial sampling is too limited to convert the catch biomass to catch numbers, which would allow the model to track numbers. It thus converts the survey numbers to biomass using available shell height/meat weight conversion data, which is limited for SPA 1. It was noted that the weights are assumed in the model and it would be worthwhile investigating how these might be extracted and applied to the survey numbers. In this case, the survey indicator would be in numbers, not biomass.

- It was recommended that the possibility of extracting individual weight information from the model be investigated to allow the model to directly use survey numbers.

Natural Mortality

Contrary to many assessments, that of scallops has the benefit of direct observation of the results of natural mortality (M) – the presence of clappers (empty attached shells). It was noted that not all natural mortality processes result in clapper production. However, the model essentially rescales the clapper-derived M to the overall M, assuming that clapper M is a constant proportion of the overall M.

In 1989, a very large year-class entered the population that caused biomass to rise many times higher than extant levels. Another large year-class now appears to be entering the population. It was noted that episodic 'events' such as these are experienced about every 10 – 12 years in the Georges Bank resource and may be characteristic of scallop populations. It is speculated that the natural mortality processes between these events are different than during each. The model uses the Dickie relationship to calculate M:

$$dC/dt = ML - DC$$

Where C = clapper abundance
M = natural mortality rate
L = abundance of living scallops
D = clapper dissolution rate

Therefore the rate of change of clapper abundance is a balance between the rate of clapper production and the rate of clapper disappearance.

It was noted that the model assumes that the rates are in equilibrium, which could be expected during the interim period and indeed the model provided M estimates close to the expected 0.1 during the this time. However, during the recruitment events, the situation is not in equilibrium and spurious M estimates are likely being produced. A number of processes that would modify the Dickie equation were discussed. Specifically, M is likely a non-linear function of L due to density dependence (perhaps disease related). D may be a linear function of fishing mortality and / or temperature. Also, dC/dT may not necessarily be an exponential function of time. It could be changing suddenly ('popcorn' model). Such assumptions on the transient states of the relationship are important to interpretation of trends in natural mortality. It is evident that further exploration of the clapper – M relationship is needed to better determine the true M during the recruitment events. Also, it will be important to understand this relationship, as it will influence the harvesting strategy adopted during an event. Some exploration of changes to the equation were undertaken that require further development.

- It was recommended that the Dickie clapper – M equation be modified to incorporate the influence of fishing mortality, density dependence, temperature, etc and be used in the assessment model; consideration should be given to the use of prior information on D.

Treatment of Error

The observation was made that use of the process error parameter might be allowing the model to fit the trends in biomass and M well but producing trends in process error term. Inclusion of this term might be hiding structural problems in the model. It was questioned what this term was measuring – presumably some process that is not formally incorporated into the model such as changes in growth? If the model were describing the main processes in the population, trends in the process error would be unexpected. It was suggested to add processes to model sequentially and see how process error term changes.

- It was recommended that the model behaviour be investigated with and without the process error term to determine its impact; residual trends in the model should be examined to determine whether or not significant processes are missing from the model.

It was noted that the model accounts for between series variance (through inclusion of the observation error terms) but not within series variance. It was suggested that error terms could be added to the model in a multiplicative manner, thus simultaneously addressing within and between series variance.

- It was recommended that error terms be used in the model to a simultaneously address within and between series variance in a multiplicative manner.

Bayesian Approach

The model described population dynamics as a state – space or time series process. It had a number of non-linearities and non-normal distributions and thus could not use the Kalman Filter. Thus Bayes Theorem was employed. It was countered in discussion that the model could have been formulated as one of observation error, rather than state space as there appeared to be few cycles in the population dynamics that needed description. Further investigation of the benefits of using state space or an observation error approach is needed.

- It was recommended that an observation error model using historical catch data as numbers be developed; this would be compared with a like state-space model to allow understanding of implications of model approach on outputs.

The model used diffuse priors for many of the parameters. This raised the question as to the utility of these. Also, it is possible that non-informative priors could 'interact' in the model to produce misleading prior dynamics. If there is little information in the priors, perhaps use of the likelihoods themselves is sufficient. This discussion raised a number of issues in relation to the Bayesian approach – when to use and not to use it, how to define priors, what output diagnostics to use, etc. There was general recognition of the need for further exploration of these issues in a methods working group environment. It was mentioned that such a group is currently being set up between Canada and the USA, and could be given this agenda item.

- It was recommended that a diagnostic toolbox for Bayesian models be developed.

DECISION RULE OPTIONS

Production Dynamics

As stated above, the assessment model does not explicitly include stock/recruit dynamics. It was realized however that how one interprets the recruitment events is critical to the management of the fishery. If these are being produced by some process occurring in the local stock, then this will influence the management actions. However, if the recruitment events are externally produced, management actions might be different. While some stock / recruit relationship within the local resources is likely, the consensus was that the recruitment events are externally driven.

- It was recommended that until further knowledge is accumulated that the recruitment events be managed separately from the interim periods.

It was mentioned that there is an opportunity to learn more of the population dynamics if fishing plans are established to investigate the system (e.g. adaptive management approach)

Catch Reference Point

As no expected changes in regulations such as shell height, season, etc. are pending, the main regulatory tool of fishing mortality will, in the short term at least, be the Total Allowable Catch (TAC). It was queried whether or not historical catches could be used to provide reference points to guide harvesting. However, while the historical catches appear sustainable, they are not necessarily reflective of biomass. Therefore, they shouldn't be used to develop reference points, except perhaps for SPA 4.

Biomass Reference Point

The discussion on the stock / recruitment dynamics raised the issue of a minimum spawning biomass as a limit. While the recruitment event might be externally driven, it was acknowledged that higher biomass may lead to more consistent recruitment. Possible biomass reference points were discussed. The Convention of the Conservation of Antarctic Marine Living Resources (CCAMLR) doesn't biomass to fall below a certain percentile (e.g. 25%) of the historical biomass. However, one based upon historical recruitment was felt superior.

- It was recommended that a biomass reference point be developed that is based upon the average historical recruitment multiplied by the yield per recruit of a population fished at $F_{0.1}$.

Fishing Mortality Reference Point

It was felt that during interim periods, a fishing mortality reference point based upon yield per recruit considerations (e.g. $F_{0.1}$) would be appropriate. However, during recruitment events, it will be necessary to develop a strategy based upon monitoring clapper ratios and simulation

of the clapper – M relationship, as discussed above. It would be important to undertake experiments to investigate the model assumptions. As well, it is expected that socio-economic considerations will play a role in determining the harvesting strategy of the recruitment events.

- It was recommended that simulation, monitoring and experimentation all play a role in defining the harvesting strategy of recruitment events.

It is expected that the harvesting strategies to use will be further explored in the Objectives Based Fisheries Management (OBFM) pilot of Bay of Fundy scallops.

CRITERIA FOR TRIGGERING AN ASSESSMENT FRAMEWORK REVIEW

The criteria used to initiate another in-depth review of the assessment model were discussed. Overall, it was agreed that a review of the assessment model should be undertaken every three to five years. In the interim, a retrospective analysis should be undertaken routinely and if this uncovers poor model behaviour, then a review should be conducted. Finally, if additional research points out the need for immediate model changes, then this should be done.

Appendix 1. List of Participants

Participant	Affiliation/Address	Telephone	FAX	E-mail
Maureen Butler	FM, Dartmouth, N.S.	(902) 426-1782		ButlerM@mar.dfo-mpo.gc.ca
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Jim Jamieson	DFO/FMR, Dartmouth, N.S.	(902) 426-8981	(902) 426-9683	JamiesonJE@mar.dfo-mpo.gc.ca
Mark Lundy	IFD/BIO, Dartmouth, N.S.	(902) 426-3733	(902) 426-1862	LundyM@mar.dfo-mpo.gc.ca
Rene Lavoie	IDF/BIO, Dartmouth, N.S.	(902) 426-2147	(902) 426-6250	LavoieR@mar.dfo-mpo.gc.ca
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Robert O'Boyle	RAP/BIO, Dartmouth, N.S.	(902) 426-3526	(902) 426-5435	Oboyler@mar.dfo-mpo.gc.ca
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Appendix 2. Letter of Invitation

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3 October 2001

Distribution

Subject: Bay of Fundy Scallop RAP: 10- 12 October 2001

The assessment framework for Bay of Fundy scallop will be reviewed in the Hayes Boardroom, Fish Lab, BIO during 10-12 October 2001. The meeting will start at 9:00am on the 10th and is planned to adjourn at 5:00pm on the 12th. I invite you to attend this meeting.

The meeting terms of reference are attached. They point out that, contrary to other RAP meetings, this meeting is reviewing the assessment framework, e.g. the methodologies used in the assessment, rather than providing a view of the stock status. The meeting will also develop decision rule options for broader discussion with industry .It promises to be an interesting meeting, the first of its type for RAP .

Could you please let me know at your earliest convenience if you will be attending (902 426-7070 or myrav@mar.dfo-mpo.gc.ca).

We greatly appreciate your contribution to this valuable exercise.

Sincerely,

Original Signed by:

Robert O'Boyle

Canada

Appendix 3. Meeting Remit

RAP Workshop on
Bay of Fundy Scallops
10 – 12 Oct 2001
Hayes Boardroom
Bedford Institute of Oceanography

Background

The 2000 DFO National Stock Assessment Program Review recommended that the assessment process move toward a system of Intensive Fishery Evaluations (IFE) in which the management framework (assessment plus decision rules) would be reviewed outside of the management schedule. This framework would be applied thereafter by science groups to provide harvest advice as part of management schedule. In June 2001, the Maritimes RAP Coordination Committee agreed to adopt this approach, realizing that in the short term, it might only be possible to review the assessment component of an IFE. Bay of Fundy (BoF) scallop had been chosen as a pilot resource for DFO's Objective Based Fishery Management (OBFM) exercise, for which an IFE would provide the technical basis. It was therefore decided to conduct an in-depth review of the BoF scallop assessment framework during 17 – 19 September 2001. This will allow time for subsequent application of the framework to provide harvest advice for the upcoming fishing season.

Terms of Reference

In support of the Oct 2001 – Sept 2002 fishing season for SFA 1 – 7 (excluding 2) scallop, undertake the following:

- Overview of types of data (commercial, sampling, survey) available for the assessment of this resource.
- Review of assessment framework, including:
  - Consideration of an assessment framework based on Bayes Theorem;
  - Consideration of alternate frameworks that may become available either before or during the workshop;

Atelier du PCR sur le
pétoncle de la baie de Fundy
du 10 au 12 octobre 2001
Salle de conférences Hayes
Institut océanographique de Bedford

Renseignements de base

Dans le cadre de l'examen du Programme national d'évaluation des stocks du MPO ayant eu lieu en 2000, il a été recommandé que le processus d'évaluation soit orienté vers un système d'évaluations de pêches intensives (EPI), dans lequel le cadre de gestion (évaluation, plus règles décisionnelles) serait examiné hors du calendrier de gestion. Les groupes scientifiques utiliseraient ensuite ce cadre pour formuler des avis sur la récolte à l'intérieur du calendrier de gestion. En juin 2001, le Comité de coordination du PCR des Maritimes a convenu d'adopter cette façon de procéder, conscient qu'à court terme on ne pourrait peut-être examiner que la composante évaluation d'une EPI. On a choisi le stock de pétoncles de la baie de Fundy pour un projet-pilote de gestion des pêches axées sur les objectifs, dont la base technique serait une EPI. Il a donc été décidé de procéder à un examen approfondi du cadre d'évaluation du stock de pétoncles de la baie de Fundy du 17 au 19 septembre 2001, afin d'avoir ensuite suffisamment de temps pour appliquer ce cadre à la formulation d'avis sur la récolte concernant la prochaine saison de pêche.

Cadre de référence

En préparation pour la saison de pêche d'octobre 2001 à septembre 2002 dans les ZPP 1-7 (à l'exclusion de la zone 2), entreprendre les activités suivantes :

- Faire un survol du type de données (de la pêche commerciale, de l'échantillonnage, des relevés) disponibles pour l'évaluation de la ressource considérée ici.
- Étudier un cadre d'évaluation et notamment :
  - Envisager un cadre d'évaluation fondé sur le théorème de Bayes;
  - Envisager d'autres cadres d'évaluation pouvant être proposés avant ou pendant l'atelier;

- Selection of assessment framework for upcoming fishing season: it is expected that this framework would be used for the subsequent fishing seasons until the need for a new framework becomes apparent.

- Development of decision rule options for broader discussion with industry.

- Development of criteria to be used which would trigger a new in-depth review.

Products

CSAS Proceedings documenting framework to be used for management.

Participation

By invitation:
- Scientific experts from within and external to DFO
- Industry knowledgeable in scallop fisheries
- Fisheries managers

- Choisir un cadre d'évaluation pour la prochaine saison de pêche: il s'agirait d'un cadre qui serait aussi utilisé pour les saisons de pêche subséquentes, jusqu'à ce qu'on estime nécessaire d'avoir un nouveau cadre.

- Élaborer des propositions de règles décisionnelles destinées à une plus large discusssion avec l'industrie.

- Élaborer les critères qui déclencheraient un nouvel examen approfondi.

Produits

Compte rendu du SCCS reflétant le cadre qui doit servir à la gestion.

Participation

Sur invitation :
- Experts scientifiques du MPO et de l'extérieur
- Membres de l'industrie connaissant la pêche du pétoncle
- Gestionnaires des pêches

Appendix 4. Research Recommendations

DATA CONSIDERATIONS

Commercial Catch, Effort and Sampling

- It was recommended that the assumptions made to partition the historical catch and effort date by SPA be reviewed and changes made as appropriate.
- It was recommended that the historical catch sampling information be explored to corroborate the model results.
- It was recommended that a catch/effort standardization be used to produce the CPUE indicator.

Surveys

- It was recommended that the entire survey time series be sued to develop stock indicators.
- It was recommended that commercial catches be used to examine long-term changes in the proportion of biomass inside and outside of the core survey area.
- It was recommended that the year-class continuity in the survey series be examined.

MODEL CONSIDERATIONS

States

- It was recommended that the model assess age groups rather than size groups in the fishable population; this model would form the basis for the further development.

Indicator – State Relationships

Commercial Catch Rate

- It was recommended that a survey indicator be developed for the age 5+ biomass. Then a power relationship between CPUE and model age 5+ biomass could be investigated.
- It was recommended that the sensitivity of the model to the reporting variance parameter be investigates.

Survey Catch Rates

- It was recommended that the possibility of extracting individual weight information from the model be investigated to allow the model to directly use survey numbers.

Natural Mortality

- It was recommended that the Dickie clapper – M equation be modified to incorporate the influence of fishing mortality, density dependence, temperature, etc., and be used in the assessment model; consideration should be given to the use of prior information on D.

Treatment of Error

- It was recommended that the model behaviour be investigated with and without the process error term to determine its impact; residual trends in the model should be examined to determine whether or not significant processes are missing from the model.

- It was recommended that error terms be used in the model to a simultaneously address within and between series variance in a multiplicative manner.

Bayesian Approach

- It was recommended that an observation error model using historical catch data as numbers be developed; this would be compared with a like state-space model to allow understanding of implications of model approach on outputs.

- It was recommended that a diagnostic toolbox for Bayesian models be developed.

DECISION RULE OPTIONS

Production Dynamics

- It was recommended that until further knowledge is accumulated, that the recruitment events be managed separately from the interim periods.

Biomass Reference Point

- It was recommended that a biomass reference point be developed that is based upon the average historical recruitment multiplied by the yield per recruit of a population fished at $F_{0.1}$.

Fishing Mortality Reference Point

- It was recommended that simulation, monitoring, and experimentation all play a role in defining the harvesting strategy of recruitment events.